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(54) **SYSTEMS AND METHODS FOR TESTING MICROELECTRONIC IMAGERS AND MICROFEATURE DEVICES**

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G01R 31/26 (2006.01)
H01L 27/00 (2006.01)

(52) **U.S. Cl.** **324/765**; 324/757; 324/753; 250/208.1; 438/17

(58) **Field of Classification Search** 324/765, 324/753
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,143,588 A * 11/2000 Glenn 438/116
6,639,418 B1 * 10/2003 Tseng 324/765
6,734,419 B1 * 5/2004 Glenn et al. 250/239
6,881,974 B1 * 4/2005 Wood et al. 257/48
6,885,101 B1 * 4/2005 Storli 257/737
6,946,325 B1 * 9/2005 Yean et al. 438/112
2004/0035917 A1 * 2/2004 Koopmans 228/215
2005/0206401 A1 * 9/2005 Caldwell et al. 324/757
2006/0197545 A1 * 9/2006 Caldwell et al. 324/757

* cited by examiner

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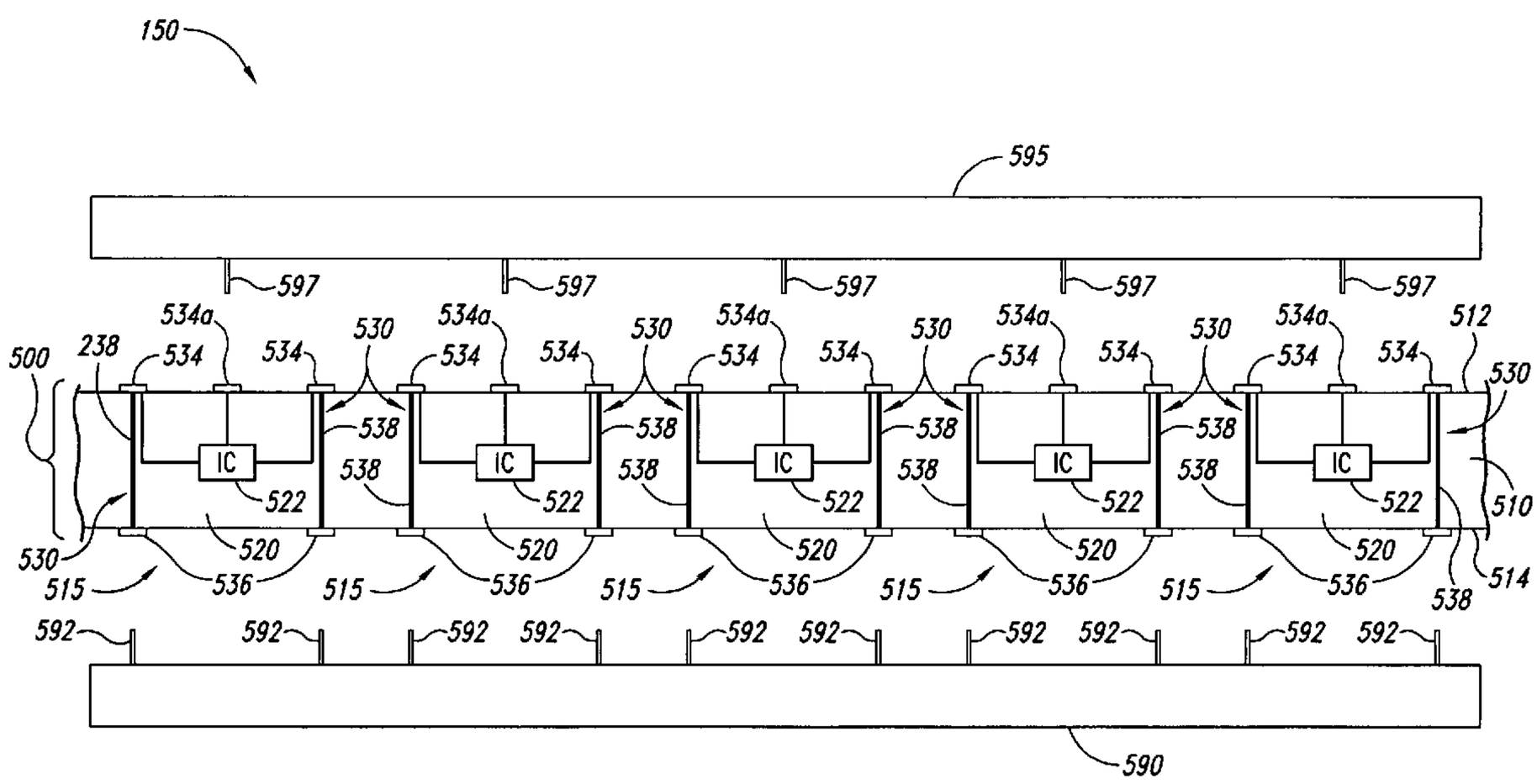
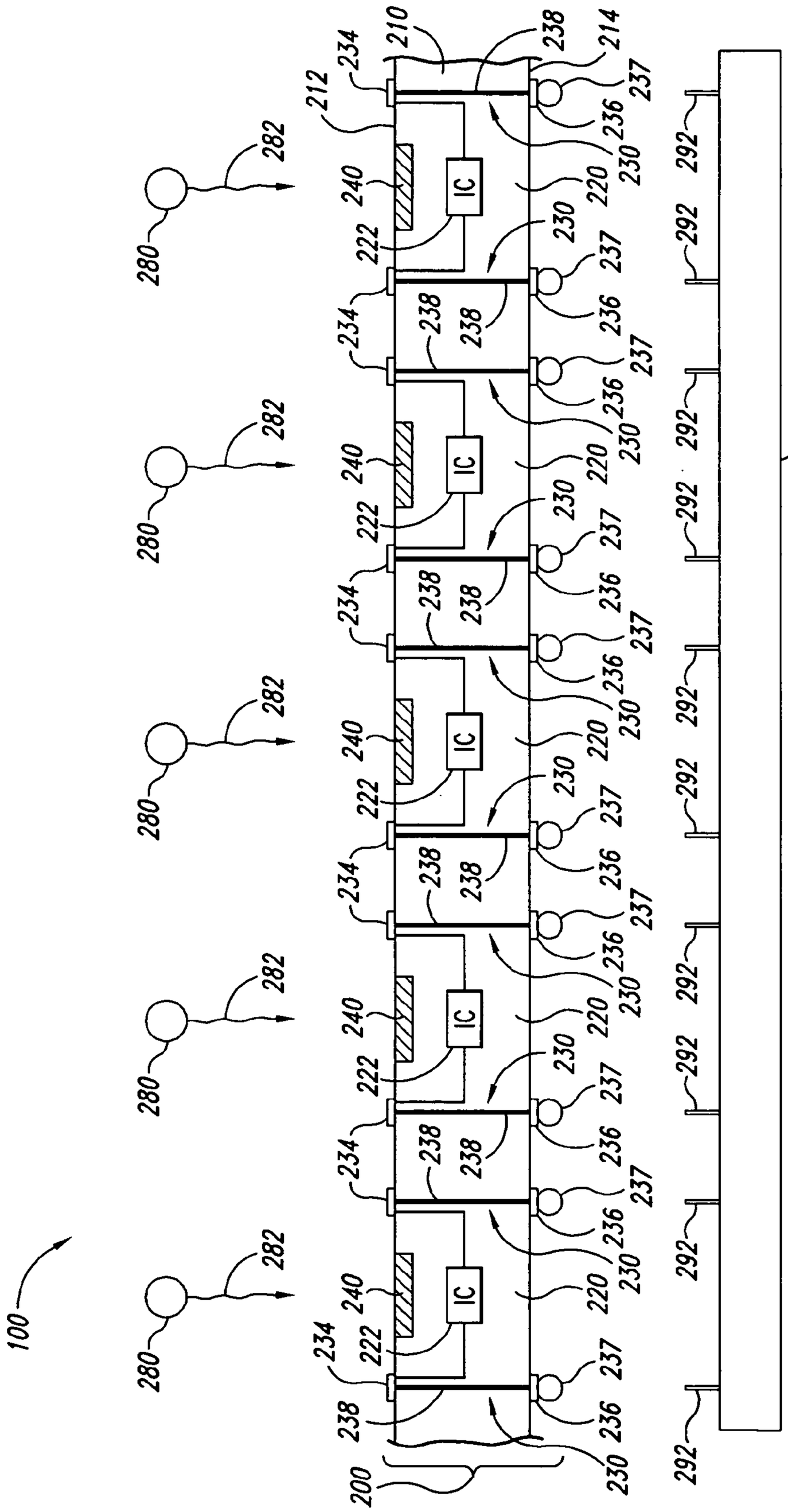
(57) **ABSTRACT**

Systems and methods for testing microelectronic imagers and microfeature devices are disclosed herein. In one embodiment, a method includes providing a microfeature workpiece including a substrate having a front side, a backside, and a plurality of microelectronic dies. The individual dies include an integrated circuit and a plurality of contact pads at the backside of the substrate operatively coupled to the integrated circuit. The method includes contacting individual contact pads with corresponding pins of a probe card. The method further includes testing the dies. In another embodiment, the individual dies can further comprise an image sensor at the front side of the substrate and operatively coupled to the integrated circuit. The image sensors are illuminated while the dies are tested.

32 Claims, 7 Drawing Sheets

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200
210
212
214
220
222
230
234
236
237
238
240
280
282
290
292
IC

Fig. 1

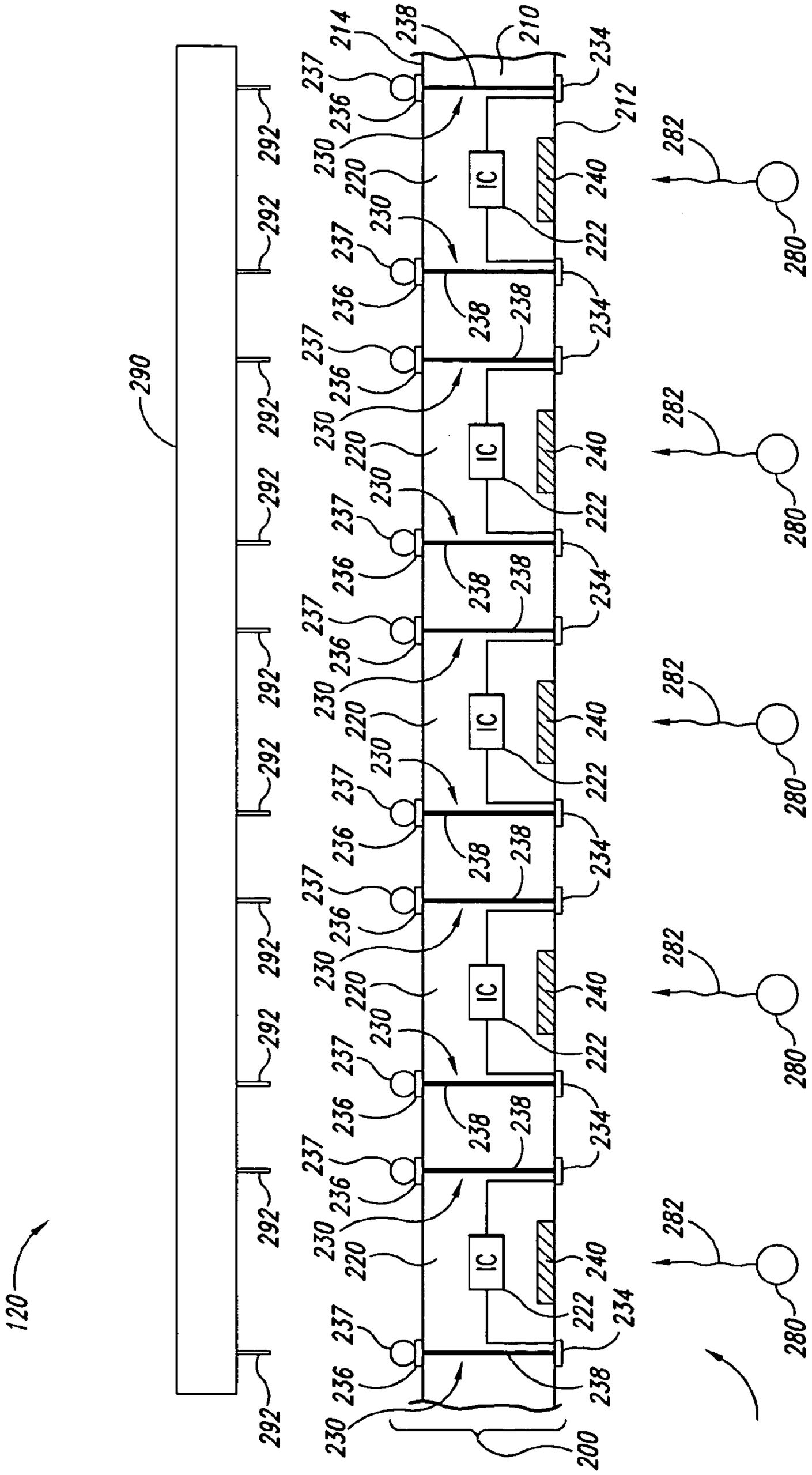

120
290
292
200
210
212
214
220
222
230
234
236
237
238
240
280
282
IC

Fig. 2

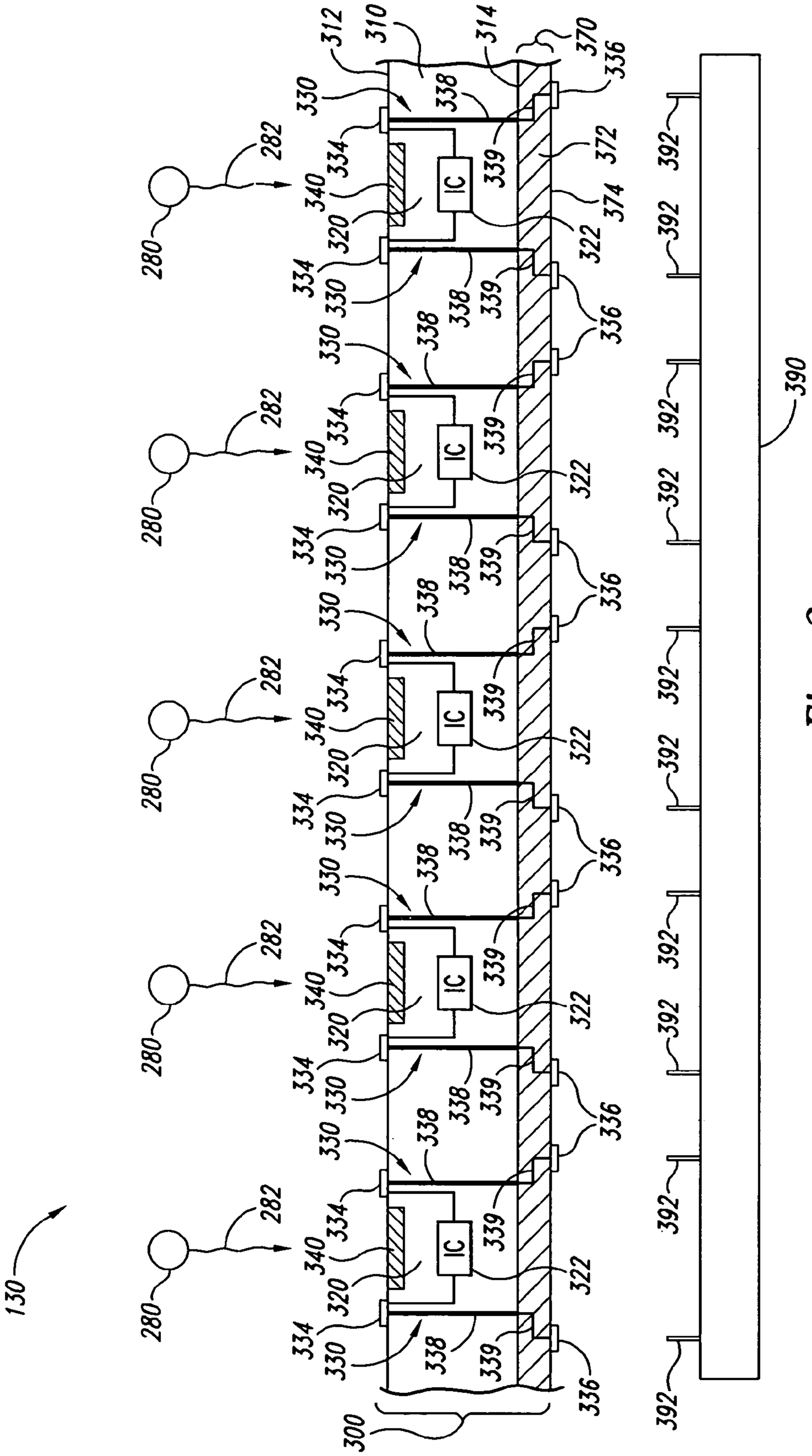

130
280
282
300
310
312
314
320
322
330
334
336
338
339
340
370
372
374
392
IC

Fig. 3

LASER
480
481
482
140
280
282
IC
200
210
212
214
220
222
230
234
236
237
238
240
290
292
484

Fig. 4

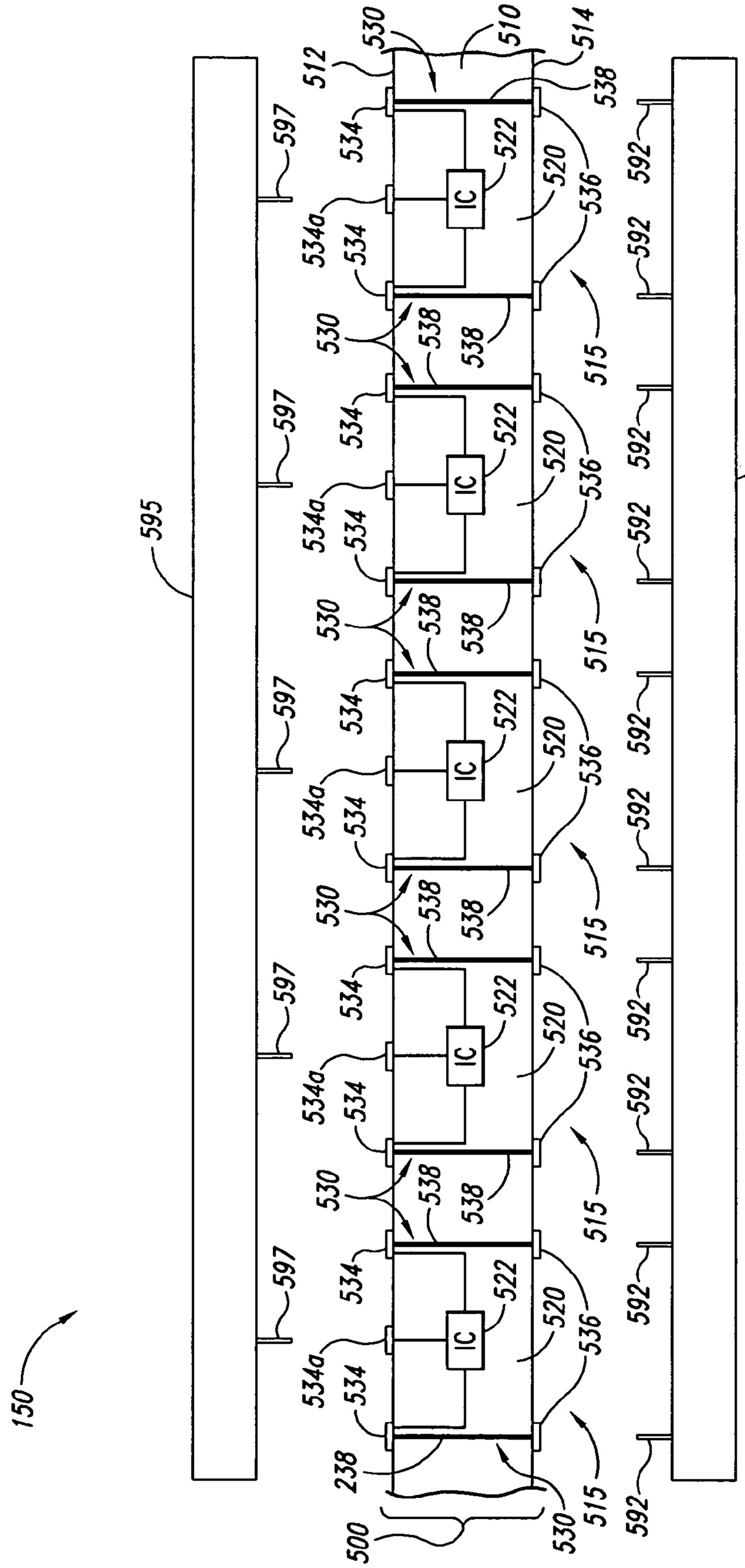
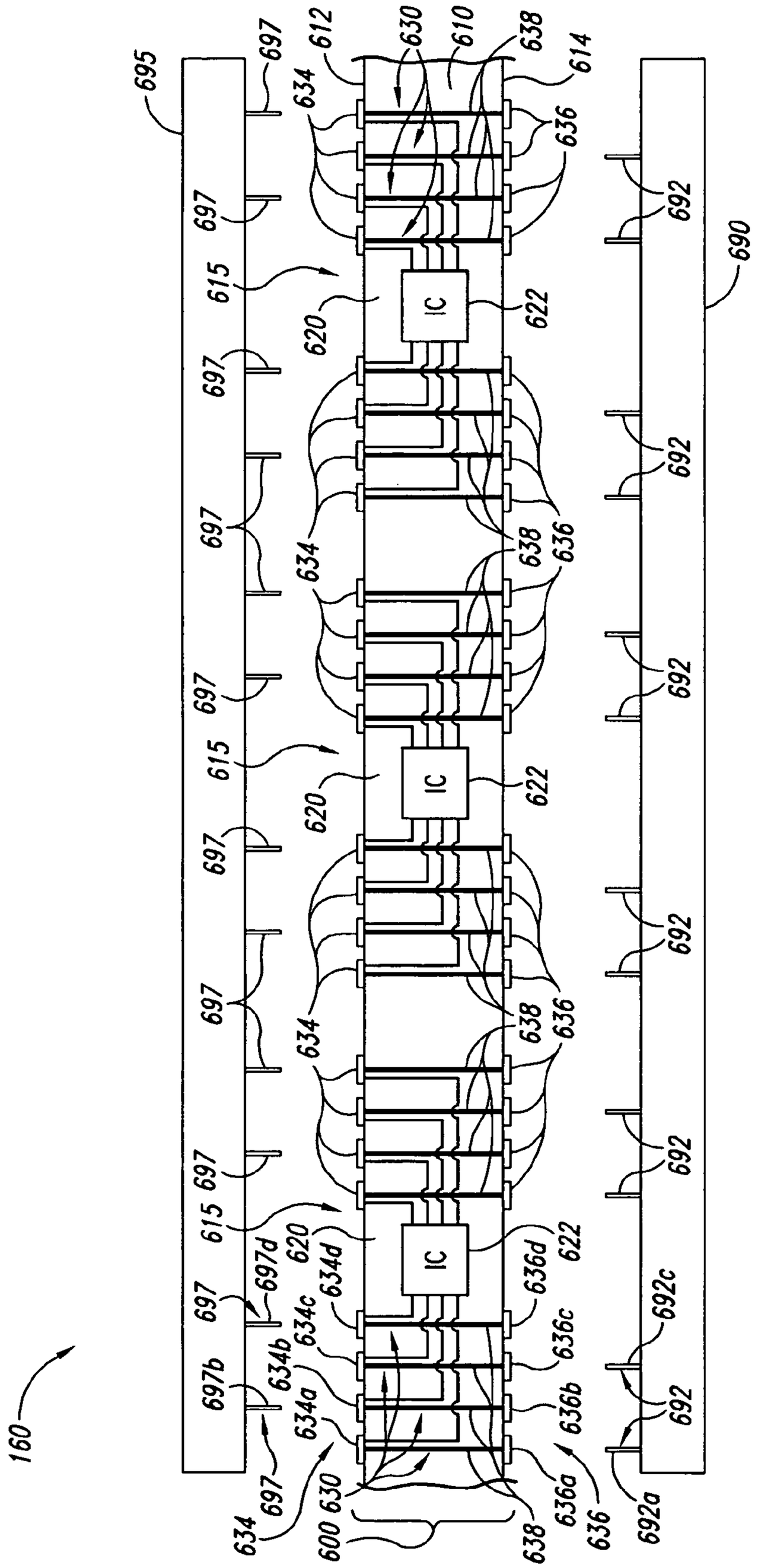

150
595
597
590
592
IC
510
512
514
515
520
522
530
534
534a
536
538
238
500

Fig. 5


160
695
697
612
630
610
638
614
634
636
692
690
615
620
IC
622
697d
634d
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697b
634b
634a
634c
636c
636b
636a
692c
692a
600

Fig. 6

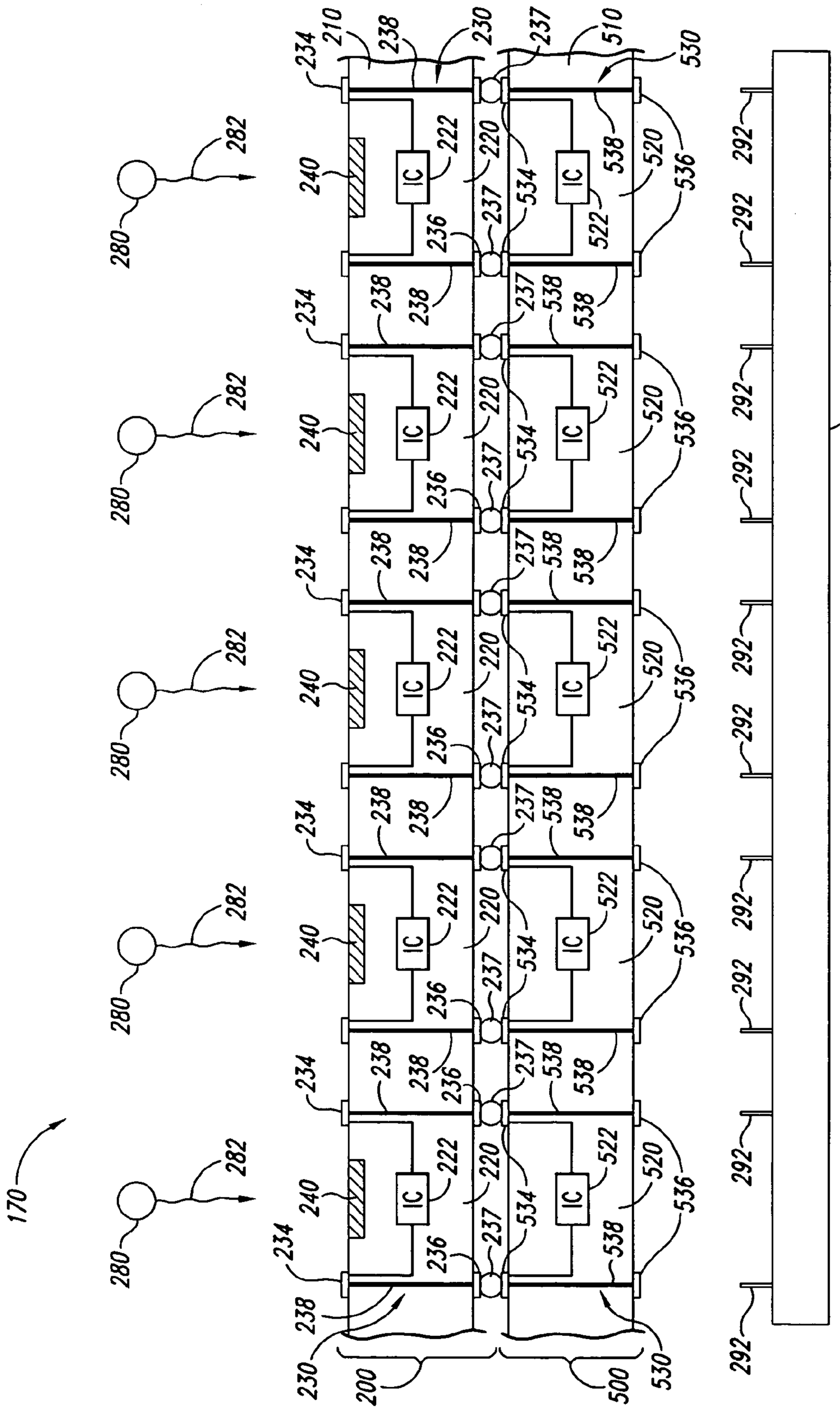
170
280
282
IC
200
500
210
220
222
230
234
236
237
238
240
290
292
510
520
522
530
534
536
538

Fig. 7

SYSTEMS AND METHODS FOR TESTING MICROELECTRONIC IMAGERS AND MICROFEATURE DEVICES

TECHNICAL FIELD

The present invention is related to systems and methods for testing microelectronic imagers and microfeature devices.

BACKGROUND

The microelectronics industry is highly competitive and microelectronics manufacturers are very sensitive to quality and cost considerations. Most microelectronics manufacturers require that suppliers of microelectronic components test the performance of each microelectronic component before shipment to minimize the manufacturer's product losses. For example, microelectronic imagers are commonly tested by establishing temporary electrical connections between a test system and electrical contacts on each microelectronic imaging die while simultaneously exposing an image sensor on the device to light.

One way of establishing a temporary electrical connection between the test system and the contacts on a microelectronic component employs a probe card carrying a plurality of probe pins. The probe pins are typically either a length of wire (e.g., cantilevered wire probes) or a relatively complex spring-biased mechanism (e.g., pogo pins). The probe pins are connected to the probe card and arranged in a predetermined array for use with a specific microelectronic component configuration. For example, when testing a microelectronic imager with a conventional probe card (whether it be a cantilevered wire probe card, a pogo pin probe card, or another design), the probe card is positioned proximate to the front side of the imaging die to be tested. The probe card and the imaging die are aligned with each other in an effort to precisely align each of the probe pins of the probe card with a corresponding electrical contact of the front side of the imaging die.

One problem with testing imaging dies at the wafer level is that it is difficult to expose an image sensor to light while simultaneously aligning the probe pins or the body of the probe card with the corresponding electrical contacts on the front side of the imaging die. For example, because the probe card is positioned over the image sensor to contact the front side bond-pads on the die, the probe card must have a plurality of holes or apertures through which light can pass. This limits wafer-level testing methods because the physical constraints of probe card structures and the limited testing area available on the wafer. Further, the probe card and/or probe pins positioned proximate (but not over) the image sensor also interfere with the light directed to the image sensor (e.g., shadowing, reflections). These limitations result in the ability to test only a fraction of the imaging dies on a wafer of imaging dies as compared to the number of other types of dies that can be tested in non-imaging applications (e.g., memory, processors, etc.). For example, only four CMOS imaging dies can be tested simultaneously on a wafer compared to 128 DRAM dies using the same equipment. Accordingly, there is a need to improve the efficiency and throughput for testing imaging dies.

Another problem with conventional probe card testing methods is that the testing process can introduce moisture and/or other contaminants to the image sensors. For example, conventional probe cards and/or probe pins are positioned over the image sensors to contact the bond-pads

on the front side of the dies. Accordingly, tiny particles generated during the testing process or otherwise on the probe pins can fall onto the image sensors. This can cause a malfunction or failure because a particle as small as ten microns can effectively ruin an image sensor. Accordingly, there is a further need to improve the testing of imaging dies.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic side cross-sectional view of a system for testing a plurality of microelectronic imaging dies in accordance with one embodiment of the invention.

FIG. **2** is a schematic side cross-sectional view of a system for testing a plurality of microelectronic imaging dies in accordance with another embodiment of the invention.

FIG. **3** is a schematic side cross-sectional view of a system for testing a plurality of microelectronic imaging dies in accordance with another embodiment of the invention.

FIG. **4** is a schematic side cross-sectional view of a system for testing a plurality of microelectronic imaging dies while simultaneously repairing fuses on a workpiece in accordance with one embodiment of the invention.

FIG. **5** is a schematic side cross-sectional view of a system for testing a plurality of microfeature devices in accordance with one embodiment of the invention.

FIG. **6** is a schematic side cross-sectional view of a system for testing a plurality of microfeature devices in accordance with one embodiment of the invention.

FIG. **7** is a schematic side cross-sectional view of a system for testing a plurality of microelectronic imaging dies along with a plurality of microfeature devices in accordance with one embodiment of the invention.

DETAILED DESCRIPTION

A. Overview

The present invention is directed toward systems and methods for testing microelectronic imagers and microfeature devices. The term "microfeature device" is used throughout to include microelectronic devices, micromechanical devices, data storage elements, read/write components, and other articles of manufacture. For example, microfeature devices include SIMM, DRAM, flash-memory, ASICS, processors, flip chips, ball-grid array chips, and other types of electronic devices or components. Several specific details of the invention are set forth in the following description and in FIGS. **1**–**7** to provide a thorough understanding of certain embodiments of the invention. One skilled in the art, however, will understand that the present invention may have additional embodiments or that embodiments of the invention may be practiced without several of the specific features described below.

One aspect of the invention is directed to methods for testing microfeature devices and microelectronic imaging dies from a backside of a workpiece. In one embodiment, a method includes providing a microfeature workpiece including a substrate having a front side, a backside, and a plurality of microelectronic dies. The individual dies include an integrated circuit and a plurality of contact pads at the backside of the substrate operatively coupled to the integrated circuit. The method further includes contacting individual contact pads with corresponding pins of a probe card and testing the dies.

Another embodiment of a method for testing microfeature devices in accordance with the invention includes testing microelectronic imaging dies. The method comprises providing a microfeature workpiece including a substrate having a front side, a backside, and a plurality of microelectronic imaging dies. The individual dies include an image sensor, an integrated circuit electrically coupled to the image sensor, a plurality of contact pads at the backside of the substrate, and through-wafer interconnects extending at least partially through the substrate and electrically coupling corresponding contact pads to the integrated circuit. The method includes contacting individual contact pads at the backside of the substrate with corresponding pins of a probe card. The method then includes illuminating the image sensors while testing the dies.

Another embodiment of a method for testing microfeature devices in accordance with the invention includes testing the microfeature devices from both the front side and backside. The method comprises providing a microfeature workpiece including a substrate having a plurality of microelectronic dies. The individual dies have an integrated circuit, a plurality of terminals at the front side of the substrate operatively coupled to the integrated circuit, a plurality of contact pads at the backside of the substrate operatively coupled to the integrated circuit, and through-wafer interconnects extending through the substrate and electrically coupling the terminals to corresponding contact pads. The method further includes contacting individual terminals with corresponding pins of a first probe card while contacting individual contact pads with corresponding pins of a second probe card. The contact pads being contacted by the second probe card are not in electrical contact with the terminals being contacted by the first probe card. The method then includes testing the dies.

Another aspect of this invention is directed toward systems for testing microfeature devices and microelectronic imaging dies. One embodiment of a system in accordance with the invention comprises a microfeature workpiece including a substrate having a plurality of microelectronic dies. The individual dies include an integrated circuit and through-wafer interconnects extending through at least a portion of the substrate and operatively coupled to the integrated circuit. The dies further include a plurality of contact pads at the backside of the substrate and operatively coupled to the integrated circuit. The system also includes a probe card having a plurality of pins positioned to contact corresponding contact pads and test the dies.

B. Embodiments of Methods for Testing Microelectronic Imaging Dies

FIG. **1** is a schematic side cross-sectional view of a system **100** for testing a plurality of microelectronic imaging dies in accordance with an embodiment of the invention. The system **100** is configured for testing of a plurality of imaging dies to verify and ensure that the imaging dies function according to specification.

The system **100** illustrated in FIG. **1** includes a microfeature workpiece **200**. The microfeature workpiece **200** includes a substrate **210** having a front side **212**, a backside **214**, and a plurality of imaging dies **220** formed on and/or in the substrate **210**. The individual imaging dies **220** can include an image sensor **240**, an integrated circuit **222** coupled to the image sensor **240**, and external contacts **230** electrically coupled to the integrated circuit **222**. The image sensors **240** can be CMOS image sensors or CCD image sensors for capturing pictures or other images in the visible spectrum, but in other embodiments the image sensors **240** can detect radiation in other spectrums (e.g., IR or UV ranges). The image sensors **240** are typically located at the front side **212** of the substrate **210**.

The external contacts **230** shown in FIG. **1** provide a small array of ball-pads within the footprint of each imaging die **220**. Each external contact **230**, for example, can include a terminal **234** (e.g., a bond-pad), an external contact pad **236** (e.g., a ball-pad), and an interconnect **238** coupling the terminal **234** to the contact pad **236**. In another aspect of this embodiment, a solder ball **237** is attached to each contact pad **236** to provide an external connection to other electronic devices (e.g., probe cards) on the backside **214** of the substrate **210**. In other embodiments, the solder balls **237** may be omitted.

In the embodiment shown in FIG. **1**, the terminals **234** are on the front side **212** of the substrate **210**, the contact pads **236** are on the backside **214** of the substrate **210**, and the interconnects **238** are through-wafer interconnects that extend completely through the substrate **210** to couple the terminals **234** to the contact pads **236** and corresponding solder balls **237**. In other embodiments, however, the imaging dies **220** may not include the terminals **234** on the front side **212** of the substrate **210** such that the integrated circuit **222** is coupled directly to the contact pads **236** on the backside **214** of the substrate **210** by through-wafer interconnects that extend through only a portion of the substrate **210**, or the terminals **234** can be within the substrate **210**.

The system **100** further includes a probe card **290** positioned proximate the backside **214** of the substrate **210**. In this disclosure, the term "probe card" may encompass a variety of architectures, including both rigid structures and flexible structures and including probe assemblies adapted for testing single microelectronic components and those adapted for testing multiple devices simultaneously, such as the system **100** illustrated in FIG. **1**. The probe card **290** in the illustrated embodiment can be formed according to the methods disclosed in U.S. patent application Ser. No. 10/230,653, entitled "Probe Card, e.g., For Testing Microelectronic Components, and Methods for Making Same," filed on Aug. 29, 2002, and herein incorporated by reference in its entirety.

The probe card **290** includes a plurality of pins **292** positioned to contact corresponding contact pads **236** and/or solder balls **237** on the individual dies **220**. During testing, the pins **292** are in electrical communication with corresponding contact pads **236** and adapted to deliver and/or receive test signals (including source voltage, ground, etc.) to one more of the components being tested (e.g., image sensors **240**). The pins **292** are typically either a length of wire or a spring-biased mechanism (e.g., pogo pins). The pins **292** can be arranged on the probe card **290** in an array corresponding to an array of the contact pads **236** and/or solder balls **237** on the backside **214** of the substrate **210**.

The system **100** illustrated in FIG. **1** further includes a plurality of light sources **280** positioned above the front side **212** of the substrate **210** and configured to provide light **282** to the image sensors **240** on the imaging dies **220**. During testing, light **282** impinges on the individual image sensors **240** to test the functionality of the image sensors **240** and to ensure that the image sensors **240** function according to specification. In the illustrated embodiment, the light **282** from the light sources **280** is visible light. In further embodiments, however, the image sensors **240** can be configured to detect radiation in other spectrums (e.g., IR or UV ranges). Accordingly, the light sources **280** can be radiation sources configured to produce IR- and/or UV-range radiation for testing the image sensors **240**.

One feature of the illustrated system **100** is that the external contacts **230** provide arrays of contact pads **236** on the backside **214** of the substrate **210**. Each array of contact pads **236** is operatively coupled to a corresponding image sensor **240**. More specifically, the contact pads **236** can be located on the backside **214** of the substrate **210** because the interconnects **238** are through-wafer interconnects that extend to the backside **214** of a substrate **210**. Accordingly, the backside arrays of contact pads **236** allow the imaging units **240** to be operably coupled to the probe card **290** on the backside **214** of the substrate **210**. As such, the probe card **290** does not interfere with the image sensors **240** on the front side **212** of the substrate **210** during illumination and testing. Moreover, this feature allows a plurality of imaging dies **220** to be tested simultaneously without interference from neighboring probe cards **290** and/or pins **292**. Further, the testing process can be more accurate because the image sensors **240** on the dies **220** can be fully illuminated without shadows or reflection from the probe card **290** and/or the pins **292**.

Another feature of the illustrated system **100** is that by testing from the backside **214** of the substrate **210**, potential contamination to the image sensors **240** on the front side **212** of the substrate **210** is mitigated or even eliminated. The image sensors **240** are very susceptible to damage from contamination because, as noted above, a particle as small as ten microns can effectively ruin an image sensor. By testing from the backside **214** of the substrate **210**, particles cannot fall from the probe card **290** and/or pins **292** to the image sensors **240**. Moreover, the image sensors **240** can be covered before testing from the backside contact pads **236** to provide complete protection of the image sensors **240**.

C. Additional Embodiments of Methods for Testing Microelectronic Imaging Dies

FIGS. **2**–**4** illustrate several alternative embodiments of systems for testing microelectronic imaging dies. In each of FIGS. **2**–**4**, many of the features may be the same as those discussed above in connection with the system **100** in FIG. **1**. Accordingly, like reference numbers are used to refer to like components in FIG. **1** and in FIGS. **2**–**4**.

FIG. **2** is a schematic side cross-sectional view of a system **120** for testing a plurality of microelectronic imaging dies in accordance with another embodiment of the invention. The system **120** includes the microfeature workpiece **200**, the probe card **290**, and the light sources **280** described above with respect to FIG. **1**. The primary difference between the system **120** shown in FIG. **2** and the system **100** shown in FIG. **1** is that the orientation of the microfeature workpiece **200** is inverted in the system **120**. More specifically, the front side **214** of the substrate **210** in this embodiment is oriented in a generally downward direction, as opposed to the generally upward orientation of the front side **214** of the substrate **210** in the system **100**. The probe card **290** and the light sources **280** in the illustrated embodiment are rearranged accordingly. One feature of this embodiment is that potential contamination of the image sensors **240** is further mitigated. Because the image sensors **240** on the front side **214** of the substrate **210** are oriented in a generally downward direction, debris is less likely to accumulate on the front side **214** of the substrate **210** and/or the image sensors **240** compared to the face-up orientation shown in FIG. **1**. Accordingly, the inverted orientation of the system **120** in the illustrated embodiment can enhance the protection of the image sensors **240** during testing.

FIG. **3** is a schematic side cross-sectional view of a system **130** for testing a plurality of microelectronic imaging dies in accordance with another embodiment of the invention. In one aspect of this embodiment, the system **130** includes a microfeature workpiece **300** and a probe card **390** generally similar to the components described above with respect to FIG. **1**. The microfeature workpiece **300** includes a substrate **310** having a front side **312**, a backside **314**, and a plurality of imaging dies **320** formed on and/or in the substrate **310**. The individual imaging dies **320** can include an image sensor **340**, an integrated circuit **322** electrically coupled to the image sensor **340**, and external contacts **330** electrically coupled to the integrated circuit **322**.

The external contacts **330** shown in FIG. **3** can be generally similar to the external contacts **230** described above with respect to FIG. **1**. Each external contact **330**, for example, can include a terminal **334** (e.g., a bond-pad) at the front side **312** of the substrate **310** and an interconnect **338** in contact with the terminal **334** and extending through the substrate **310**. The workpiece **300**, however, differs from the workpiece **200** shown in FIG. **1** in that the external contacts on the backside **314** of the substrate **310** are of such a fine pitch that a redistribution assembly **370** is formed on the substrate **310**. The redistribution assembly **370** includes a dielectric layer **372**, a plurality of ball-pads **336** at a backside **374** of the redistribution assembly **370**, and a plurality of traces **339** electrically coupling the ball-pads **336** to corresponding interconnects **338**. Accordingly, the ball-pads **336** provide an external connection to other electronic devices (e.g., probe cards). In another aspect of this embodiment, a solder ball (not shown) or other conductive element can be attached to each ball-pad **336**.

The probe card **390** has a plurality of pins **392** positioned at the backside **314** of the substrate **310**. The probe card **390** differs from the probe card **290** shown in FIG. **1** in that the arrangement of the pins **392** on the probe card **390** is different. The pins **392** can be arranged in an array corresponding to the ball-pads **336** on the redistribution assembly **370**. In another aspect of the embodiment illustrated in FIG. **3**, the system **130** can further include the light sources **280** positioned above the front side **312** of the substrate **310** and configured to provide light **282** to the image sensors **340** on corresponding imaging dies **320**.

One feature of the illustrated embodiment is that the redistribution assembly **370** provides arrays of ball-pads **336** that are spaced farther apart and have more surface area than the contact pads **236** shown in FIG. **1**. This feature is particularly important when positioning and attaching the pins **392** of the probe card **390** to ball-pads arranged in the high-density, fine pitch arrays that are common in high-performance imagers.

FIG. **4** is a schematic side cross-sectional view of a system **140** in accordance with another embodiment of the invention. In one aspect of this embodiment, the system **140** can include the microfeature workpiece **200** and the probe card **290** described above in FIG. **1**. The system **140** differs from the system **100** described above with respect to FIG. **1** in that the system **140** further includes a repair apparatus **480** to fuse repair electrical connections on the substrate **210**. The repair apparatus **480** in the illustrated embodiment includes a laser **481** (shown schematically) that directs laser light **482** onto an antifuse **484** at the front side **212** of the substrate **210**. The laser light **482** irradiates the antifuse **484** on the substrate **210**, thus reflowing the antifuse **484** and restoring the electrical connection to a failed connection on the dies **220**. In other embodiments, the repair apparatus **480** can have other configurations and/or irradiate the antifuse **484** in a different manner. One feature of the illustrated embodiment is that the fuse repair process can take place at

one location on the front side **212** of the substrate **210**, while testing of the imaging dies **220** is taking place at another location on the front side **212** of the substrate **210**. Accordingly, the simultaneous repair/testing processes can result in faster throughput and lower manufacturing costs.

D. Additional Embodiments of Methods for Testing Microfeature Devices

FIGS. **5–7** illustrate systems for testing microfeature devices in accordance with additional embodiments of the invention. For example, FIG. **5** is a schematic side cross-sectional view of a system **150** including a microfeature workpiece **500** and two probe cards **590**, **595** configured for testing microfeature devices **515** on the workpiece **500**. The system **150** differs from the system **100** shown above in FIG. **1** in that the microfeature devices **515** on the workpiece **500** do not include image sensors.

The microfeature workpiece **500** in the illustrated embodiment includes a substrate **510** having a front side **512**, a backside **514**, and a plurality of microfeature devices **515** formed on and/or in the substrate **510**. The individual microfeature devices **515** include a microelectronic die **520** having an integrated circuit **522** and a plurality of external contacts **530** electrically coupled to the integrated circuit **522**.

The external contacts **530** can be generally similar to the external contacts **230** described above with respect to FIG. **1**. Each external contact **530**, for example, can include a terminal **534** (e.g., a bond-pad), an external contact pad **536** (e.g., a ball-pad), and an interconnect **538** coupling the terminal **534** to the contact pad **536**. In the embodiment shown in FIG. **5**, the terminals **534** are on the front side **512** of the substrate **510**, the contact pads **536** are on the backside **514** of the substrate **510**, and the interconnects **538** are through-wafer interconnects that extend completely through the substrate **510** to couple the terminals **534** to corresponding contact pads **536**.

In another aspect of this embodiment, the individual dies **520** include some terminals **534** (e.g., terminals **534***a*) at the front side **512** of the substrate **510** that are not in contact with interconnects **538** extending through the substrate **510**. As such, terminals **534***a* must be tested from the front side **512** of the substrate **510**. Accordingly, the system **150** includes a first probe card **590** at the backside **514** of the substrate **510** and a second probe card **595** at the front side **512** of the substrate **510**. The first probe card **590** includes a plurality of pins **592** positioned to contact corresponding contact pads **536** on the backside **514** of the substrate **510**, while the second probe card **595** includes a plurality of pins **597** positioned to contact terminals **534***a* on the front side **512** of the substrate **510**. During testing, the pins **592**, **597** are in electrical communication with the dies **520** and adapted to deliver and/or receive test power (including test signals) to one more of the components of the dies **520**. The pins **592**, **597** can be arranged on the first and second probe cards **590**, **595** in arrays corresponding to the arrays of corresponding contact pads **536** and terminals **534**, **534***a* on the substrate **510**.

One feature of the embodiment illustrated in FIG. **5** is that the use of multiple probe cards provides for simultaneous testing of both terminals **534** coupled to interconnects **538** and terminals **534***a* not coupled to interconnects **538**. Accordingly, this feature provides flexibility in the testing process in that microelectronic dies having terminals with and without connections to interconnects can be tested quickly and without additional steps being required in the testing process. Furthermore, this feature minimizes the amount of time it takes to test a workpiece since testing can occur from both the front side and the backside of the substrate.

FIG. **6** is a schematic side cross-sectional view of a system **160** in accordance with another embodiment of the invention. In the illustrated embodiment, the system **160** can include a microfeature workpiece **600** with a substrate **610** having a front side **612**, a backside **614**, and a plurality of microfeature devices **615** formed on and/or in the substrate **610**. The microfeature devices **615** can be generally similar to the devices **515** described above with respect to FIG. **5**. The individual microfeature devices **615** have a microelectronic die **620** including an integrated circuit **622** and a plurality of external contacts **630** electrically coupled to the integrated circuit **622**. Each external contact **630** can include a terminal **634** (e.g., a bond-pad) on the front side **612** of the substrate **610**, an external contact pad **636** (e.g., a ball-pad) on the backside **614** of the substrate **610**, and a through-wafer interconnect **638** extending completely through the substrate **610** coupling the terminals **634** to corresponding contact pads **636**.

The system **160** further includes a first probe card **690** having a plurality of pins **692** positioned proximate the backside **614** of the substrate **610** and a second probe card **695** having a plurality of pins **697** positioned proximate the front side **612** of the substrate **610**. The pins **692**, **697** can be arranged on the first and second probe cards **690**, **695** in arrays corresponding to the arrays of contact pads **636** and terminals **634** on the substrate **610**.

The external contacts **630** in the illustrated embodiment differ from the external contacts **530** shown in FIG. **5** in that density of the terminals **634** on the front side **612** of the substrate **610** is so great (e.g., having approximately zero pitch) that the terminals **634** cannot all be tested from one side of the substrate **610**. Accordingly, the terminals **634** must be tested by probing alternate front side terminals **634** and backside contact pads **636**.

For example, pins **692***a* and **692***c* on the first probe card **690** are in electrical communication with contact pads **636***a* and **636***c* (and accordingly terminals **634***a* and **634***c* via interconnects **638**). Terminals **634***b* and **634***d*, however, are not in electrical communication with probe card **690**. Rather, terminals **634***b* and **634***d* (and accordingly contact pads **636***b* and **636***d* via interconnects **638**) are contacted by pins **697***b* and **697***d* on the second probe card **695**. Accordingly, a plurality of dies **620** having fine-pitch arrays can be tested simultaneously by probing alternating terminals **634** and contact pads **636** on both the front side **612** and the backside **614** of the substrate **610**, even though the arrays of terminals **634** and/or contact pads **636** on the individual dies **620** are too dense for the probe cards **690**, **695**. Furthermore, construction of the probe cards **690**, **695** can be simplified because each probe card will not have to be configured to test the entire high-density array. Rather, individual probe cards will only require enough pins to test alternate electrical contacts on corresponding sides of the substrate **610**.

From the foregoing, it will be appreciated that specific embodiments of the invention have been described herein for purposes of illustration, but that various modifications may be made without deviating from the spirit and scope of the invention. Furthermore, various aspects of any of the foregoing embodiments can be combined in different combinations. FIG. **7**, for example, illustrates a system **170** that is a combination of the microfeature workpiece **200**, probe card **290**, and light sources **280** shown in FIG. **1** with the microfeature workpiece **500** from FIG. **5**. The imaging dies

220 and microelectronic dies 520 can be tested together as shown. Accordingly, the invention is not limited except as by the appended claims.

We claim:

1. A method for testing a plurality of microelectronic dies, comprising:

providing a microfeature workpiece including a substrate having a front side, a backside, and a plurality of microelectronic dies, the individual dies comprising (a) an integrated circuit, (b) a plurality of contact pads at the backside of the substrate operatively coupled to the integrated circuit, (c) an image sensor at the front side of the substrate and electrically coupled to the integrated circuit, and (d) a plurality of terminals at the front side of the substrate and electrically coupled to the integrated circuit, and wherein interconnects extend through the substrate electrically coupling the terminals to corresponding contact pads;

forming a redistribution assembly at the backside of the substrate, the redistribution assembly having a dielectric layer over the backside of the substrate, a plurality of ball-pads, and traces electrically coupling the ball-pads to corresponding contact pads;

contacting individual contact pads with corresponding pins of a probe card;

contacting the individual ball-pads with corresponding pins of the probe card;

testing the dies; and

illuminating the image sensors while testing the dies.

2. The method of claim 1 wherein the method further comprises providing a light source proximate the front side of the substrate for illuminating the image sensors while testing the dies.

3. A method for testing a plurality of microelectronic dies, comprising:

providing a microfeature workpiece including a substrate having a front side, a backside, and a plurality of microelectronic dies, the individual dies comprising (a) an integrated circuit, (b) a plurality of contact pads at the backside of the substrate operatively coupled to the integrated circuit, and (c) terminals at the front side of the substrate and electrically coupled to the integrated circuit, and wherein a plurality of through-wafer interconnects extend through the substrate electrically coupling the terminals to corresponding contact pads;

contacting individual contact pads with corresponding pins of a first probe card;

contacting the terminals at the front side of the substrate with corresponding pins of a second probe card, wherein the terminals being contacted by the second probe card are not in electrical contact with the contact pads and/or interconnects being contacted by the first probe card; and

testing the dies.

4. The method of claim 3, further comprising:

attaching a plurality of solder balls to corresponding contact pads; and

contacting the individual solder balls with corresponding pins of the probe card.

5. The method of claim 3 wherein testing the dies comprises delivering test power to the contact pads while corresponding pins are in contact with the contact pads.

6. The method of claim 3 wherein the terminals are in arrays having approximately zero pitch.

7. A method for testing a plurality of microelectronic dies, comprising:

providing a microfeature workpiece including a substrate having a front side, a backside, and a plurality of microelectronic dies, the individual dies comprising (a) an integrated circuit, (b) a plurality of contact pads at the backside of the substrate operatively coupled to the integrated circuit, and (c) an image sensor at the front side of the substrate and electrically coupled to the integrated circuit;

contacting individual contact pads with corresponding pins of a probe card;

testing the dies;

providing an antifuse at the front side of the substrate, the antifuse being out of electrical communication with at least one die;

irradiating the antifuse with a laser to restore electrical communication between the antifuse and a first die; and

while irradiating the antifuse, illuminating an image sensor on a second die spaced apart from the first die and testing the second die.

8. A method for testing a plurality of microelectronic dies, comprising:

providing a first microfeature workpiece including a first substrate having a front side, a backside, and a plurality of microelectronic dies, the individual dies comprising an integrated circuit and a plurality of contact pads at the backside of the substrate operatively coupled to the integrated circuit;

providing a second microfeature workpiece having a second substrate with a front side, a backside, and a plurality of microelectronic dies, the individual dies comprising image sensors, integrated circuits electrically coupled to the image sensors, and a plurality of external electrical contacts electrically coupled to the integrated circuits;

assembling the first substrate to the second substrate so that the external electrical contacts at the backside of the second substrate contact corresponding terminals at the front side of the first substrate, the first substrate being in electrical communication with the second substrate;

contacting individual contact pads with corresponding pins of a probe card; and

illuminating the image sensors on the second substrate while simultaneously testing the dies on the first and second substrate.

9. A method for testing a plurality of microelectronic imaging dies on a microfeature workpiece including a substrate having a front side, a backside, and a plurality of microelectronic imaging dies, the individual dies comprising an image sensor at the front side of the substrate, an integrated circuit electrically coupled to the image sensor, a plurality of contact pads at the backside of the substrate, and through-wafer interconnects extending at least partially through the substrate and electrically coupling corresponding contact pads to the integrated circuit, the method comprising:

contacting individual contact pads at the backside of the substrate with corresponding pins of a probe card;

illuminating the image sensors on the front side of the substrate;

forming a redistribution assembly at the backside of the substrate, the redistribution assembly having a dielectric layer over the backside of the substrate, a plurality of ball-pads, and traces electrically coupling the ball-pads to corresponding contact pads;

contacting the individual ball-pads with corresponding pins of the probe card; and

testing the dies.

10. The method of claim **9**, further comprising:

providing a light source proximate the front side of the substrate; and

illuminating the image sensors with the light source while testing the dies.

11. The method of claim **9** wherein:

the individual dies further comprise a plurality of terminals at the front side of the substrate and electrically coupled to the integrated circuit, wherein the interconnects extend through the substrate electrically coupling the terminals to corresponding contact pads;

providing a light source proximate the front side of the substrate; and

illuminating the image sensors with the light source while testing the dies.

12. The method of claim **9**, further comprising:

attaching a plurality of solder balls to corresponding contact pads; and

contacting the individual solder balls with corresponding pins of the probe card.

13. A method for testing a plurality of microelectronic imaging dies on a microfeature workpiece including a substrate comprising a front side, a backside, and a plurality of microelectronic imaging dies, the individual dies including an image sensor at the front side of the substrate, an integrated circuit electrically coupled to the image sensor, a plurality of contact pads at the backside of the substrate, and through-wafer interconnects extending at least partially through the substrate and electrically coupling corresponding contact pads to the integrated circuit, the method comprising:

contacting individual contact pads at the backside of the substrate with corresponding pins of a probe card;

illuminating the image sensors on the front side of the substrate;

testing the dies;

providing an antifuse at the front side of the substrate, the antifuse being out of electrical communication with at least one die;

irradiating the antifuse with a laser to restore electrical communication between the antifuse and a first die; and

while irradiating the antifuse, illuminating an image sensor on a second die out of electrical contact with the antifuse and testing the second die.

14. A method for testing a plurality of microelectronic imaging dies, comprising:

providing a plurality of microelectronic imaging dies;

providing a probe card having a plurality of pins;

contacting individual backside contact pads on a backside of the imaging dies with corresponding pins of the probe card;

illuminating image sensors on a front side of the dies while contacting the individual ball-pads with the pins of the probe card;

forming a redistribution assembly at the backside of the substrate, the redistribution assembly having a dielectric layer over the backside of the substrate, a plurality of ball-pads, and traces electrically coupling the ball-pads to corresponding contact pads; and

contacting the individual ball-pads with corresponding pins of the probe card; and

testing the dies.

15. The method of claim **14**, further comprising providing a light source above the front side of the substrate, and wherein illuminating the image sensors includes directing light from the light source onto the image sensors.

16. The method of claim **14** wherein the individual dies further comprise a plurality of terminals at the front side of the substrate and electrically coupled to the integrated circuit, and wherein interconnects extend through the substrate electrically coupling the terminals to corresponding contact pads.

17. The method of claim **14**, further comprising:

attaching a plurality of solder balls to corresponding contact pads; and

contacting the individual solder balls with corresponding pins of the probe card.

18. A method for testing a plurality of microfeature devices, comprising:

providing a microfeature workpiece including a substrate having a front side, a backside, and a plurality of microelectronic dies, the individual dies comprising (a) an integrated circuit, (b) a plurality of contact pads at the backside of the substrate, (c) through-wafer interconnects extending at least partially through the substrate and electrically coupling corresponding contact pads to the integrated circuit, and (d) terminals at the front side of the substrate and electrically coupled to the integrated circuit, wherein at least a portion of the terminals are in contact with the interconnects;

providing a first probe card having a plurality of pins;

contacting individual contact pads on the backside of the substrate with corresponding pins of the first probe card;

contacting terminals at the front side of the substrate with corresponding pins of a second probe card, wherein the terminals being contacted by the second probe card are not in electrical contact with the contact pads and/or interconnects being contacted by the first probe card; and

testing the dies.

19. The method of claim **18** wherein the terminals are in arrays having approximately zero pitch.

20. The method of claim **18**, further comprising:

attaching a plurality of solder balls to corresponding contact pads; and

contacting the individual solder balls with corresponding pins of the probe card.

21. A method for testing a plurality of microelectronic dies on and/or in a substrate, the individual dies comprising (a) an integrated circuit, (b) a plurality of contact pads at a backside of the substrate and operatively coupled to the integrated circuit, (c) a plurality of terminals at a front side of the substrates, and (d) a plurality of through-wafer interconnects extending through the substrate electrically coupling the terminals to corresponding contact pads, the method comprising:

contacting individual contact pads with corresponding pins of a first probe card;

contacting terminals at the front side of the substrate with corresponding pins of a second probe card, wherein the terminals being contacted by the second probe card are not in contact with the interconnects and/or contact pads being contacted by the first probe card; and

testing the dies.

22. The method of claim **21** wherein:

the individual dies further comprise an image sensor at a front side of the substrate, the image sensor being electrically coupled to the integrated circuit; and

the method further comprises illuminating the image sensors while testing the dies.

23. A system for testing a plurality of microfeature devices, comprising:

a microfeature workpiece including a substrate having a front side, a backside, and a plurality of microelectronic dies, the individual dies comprising an integrated circuit, interconnects extending through at least a portion of the substrate and operatively coupled to the integrated circuit, and a plurality of contact pads at the backside of the substrate and operatively coupled to the integrated circuit;

a probe card having a plurality of pins positioned to contact corresponding contact pads on the backside of the substrate and test the dies; and

a redistribution assembly at the backside of the substrate, the redistribution assembly having a dielectric layer over the backside of the substrate, a plurality of ball-pads, and traces electrically coupling the ball-pads with corresponding contact pads, and wherein the pins on the probe card are positioned to contact corresponding ball-pads.

24. The system of claim 23 wherein:

the individual dies further comprise an image sensor at the front side of the substrate and electrically coupled to the integrated circuit; and

the system further comprises a light source positioned over the image sensors and configured to provide light to the image sensors during testing of the dies.

25. The system of claim 23 further comprising a plurality of solder balls on corresponding contact pads, and wherein the pins on the probe card are positioned to contact corresponding solder balls.

26. A system for testing a plurality of microfeature devices, comprising:

a microfeature workpiece including a substrate having a front side, a backside, a plurality of microelectronic dies, and an antifuse at the front side of the substrate, the antifuse being out of electrical communication with at least one die,

the individual dies comprising (a) an integrated circuit, (b) interconnects extending through at least a portion of the substrate and operatively coupled to the integrated circuit, (c) a plurality of contact pads at the backside of the substrate and operatively coupled to the integrated circuit, and (d) an image sensor at the front side of the substrate and electrically coupled to the integrated circuit;

a probe card having a plurality of pins positioned to contact corresponding contact pads on the backside of the substrate and test the dies; and

a fuse repair apparatus having a laser positioned to irradiate the antifuse and restore electrical communication between the antifuse and a first die.

27. A system for testing a plurality of microfeature devices, comprising:

a microfeature workpiece including a substrate having a front side, a backside, and a plurality of microelectronic dies, the individual dies comprising (a) an integrated circuit, (b) interconnects extending through at least a portion of the substrate and operatively coupled to the integrated circuit, (c) a plurality of contact pads at the backside of the substrate and operatively coupled to the integrated circuit, and (d) a plurality of terminals at the front side of the substrate and electrically coupled to the integrated circuit, wherein the interconnects extend through the substrate electrically coupling the terminals to corresponding contact pads;

a first probe card having a plurality of pins positioned to contact corresponding contact pads on the backside of the substrate and test the dies; and

a second probe card at the front side of the substrate having pins positioned to contact corresponding terminals, wherein the terminals being contacted by the second probe card are not in contact with the interconnects and/or contact pads being contacted by the first probe card.

28. The system of claim 27 wherein:

the individual dies further comprise an image sensor at the front side of the substrate and electrically coupled to the integrated circuit; and

the system further comprises a light source positioned over the image sensors and configured to provide light to the image sensors during testing of the dies.

29. The system of claim 27 wherein the terminals are in arrays having approximately zero pitch.

30. A system for testing a plurality of microfeature devices, comprising:

a first microfeature workpiece including a first substrate having a front side, a backside, and a plurality of microelectronic dies, the individual dies comprising an integrated circuit, interconnects extending through at least a portion of the substrate and operatively coupled to the integrated circuit, and a plurality of contact pads at the backside of the substrate and operatively coupled to the integrated circuit;

a second microfeature workpiece having a second substrate with a front side, a backside, and a plurality of microelectronic dies, the individual dies comprising image sensors, integrated circuits electrically coupled to the image sensors, and a plurality of external electrical contacts electrically coupled to the integrated circuits, the first and second substrates being assembled together so that the external electrical contacts at the backside of the second substrate contact corresponding terminals at the front side of the first substrate, and wherein the first substrate is in electrical communication with the second substrate;

a probe card having a plurality of pins positioned to contact corresponding contact pads on the backside of the first substrate and test the dies; and

a light source positioned above the front side of the second substrate to illuminate the image sensors during testing, and wherein the probe card contacts corresponding contact pads at the backside of the first substrate to test the dies on both the first and second substrates.

31. A system for testing a plurality of microelectronic imaging dies, comprising:

a microfeature workpiece including a substrate having a front side, a backside, and a plurality of microelectronic imaging dies, the individual dies comprising an image sensor, an integrated circuit electrically coupled to the image sensor, a plurality of contact pads at the backside of the substrate, and through-wafer interconnects extending at least partially through the substrate and electrically coupling corresponding contact pads to the integrated circuit;

a light source positioned to illuminate the image sensors;

a probe card having a plurality of pins positioned to contact corresponding contact pads at the backside of the substrate and test the dies while the image sensors are illuminated; and

a redistribution assembly at the backside of the substrate, the redistribution assembly having a dielectric layer

over the backside of the substrate, a plurality of ball-pads, and traces electrically coupling the ball-pads with corresponding contact pads, and wherein the pins on the probe card contact corresponding ball-pads.

32. The system of claim **31** wherein the individual dies further comprise a plurality of terminals at the front side of the substrate and electrically coupled to the integrated circuit, wherein the interconnects extend through the substrate electrically coupling the terminals to corresponding contact pads.

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